Introduction: Concepts for lunar base structures have been proposed since long before the dawn of the space age. The emphasis below is on structures for human habitation, a technically challenging fraction of the total number of structures likely to comprise the lunar facility. The test for any proposed lunar base structure is how it meets certain basic as well as special requirements. On the lunar surface, numerous constraints must be satisfied by all designs. These are different from those for terrestrial or orbital structures, as will be discussed later. A number of structural types have been proposed for lunar base structures. These include concrete, metal frame, pneumatic, and hybrid structures. In addition, options exist for subsurface architectures and the use of natural features such as lava tubes. Each of these approaches can in principle satisfy the various and numerous constraints, but differently.

Reliability: This paper examines risk and reliability issues surrounding the establishment of structures for human habitation on the Moon. Human safety and the minimization of risk to “acceptable” levels is always a top consideration for any engineering project. The Moon offers new challenges to the engineering designer. Minimization of risk implies in particular structural redundancy, and when all else fails, easy escape to safety for the inhabitants. The key word is “acceptable.” It is a subjective deliberation, deeply rooted in economic considerations.

What is an acceptable level of safety and reliability for a lunar site, one that must be considered highly hazardous?

Such questions go beyond engineering considerations and must include policy considerations: Can we afford to fail?

Reliability is a specialized term for the analysis and design of systems where certain aspects of the environment and system have associated uncertainties. Thus, design requires explicit accounting of evolutionary processes that are inherently nondeterministic. This fact makes estimation of risk and reliability design complex activities.

The problem of designing a structure for construction on the lunar surface is a difficult one, discussed here only in relation to risk and reliability. Some important considerations necessary in a detailed reliability study include:

- the relationships between severe lunar temperature cycles and structural and material fatigue, a problem for exposed structures,
- structural sensitivity to temperature differentials between different sections of the same component,
- very low-temperature effects and the possibility of brittle fractures,
- outgassing for exposed steels and other effects of high vacuum on steel, alloys, and advanced materials,
- factors of safety, originally developed to account for uncertainties in the Earth design and construction process, undoubtedly need adjustment for the lunar environment, either up or down depending on one's perspective and tolerance for risk.

Many of these considerations are well understood in a basic sense, and need to be expanded upon for the lunar site. Some of these discussions have started, in particular regarding the design process for an extraterrestrial structure. Specifically:

- What failure rate is acceptable?
- What factors of safety, and levels of redundancy, are necessary to assure this failure rate?
- What failure rate is acceptable?

Next, man-made risks are to be assessed. What factors of safety, and levels of redundancy, are necessary to assure this failure rate?

Redundancy is a separate question. Once a basis has been set for acceptable risk and safety factors, the designer must be ingenuous in the conceptual design, optimizing the design so that overall risk is as close as possible to the acceptable level. In addition, risk should be distributed throughout the site in accordance with the criticality of the various parts to the overall mission. This is a difficult problem, requiring the study of competing structural concepts.

Other related studies must be made of: logistics, inventories, payload delivery options, redundancy of design, ease of repair and reconditioning, smart and self-repairing systems. A detailed introduction and discussion is provided in [1].